THE IMPACT OF FIRE UPON THE SIZE AND FLOWERING OF THREE HONEY POSSUM FOODPLANTS AT THE WESTERN END OF THE FITZGERALD RIVER NATIONAL PARK, WESTERN AUSTRALIA

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ABSTRACT

The Honey Possum (*Tarsipes rostratus*) is a tiny marsupial found only in the south-west of Western Australia. It feeds exclusively upon pollen and nectar. The mediterranean climate of this area means that the area is prone to recurrent fires. Fire can often have a severe impact on the availability of resources required by small mammals for their survival.

During a long-term study of the impact of fire upon the Honey Possum in the Fitzgerald River National Park (FRNP) on the south-west coast of Western Australia, the impact of fire upon size and flowering of three of its preferred foodplants was studied.

All three species of foodplants were recorded at four study areas, last burnt some 5, 13, 23 and > 50 years earlier. Despite substantial variation between plants at each area, those areas unburnt for longer had taller plants bearing more inflorescences. The results obtained clearly indicate that fire can have a severe impact of the availability of the inflorescences favoured by these small marsupials. The increase in Honey Possums with increasing time since fire, and maximal captures in areas unburnt for some 30 years, corresponds well to the availability of foodplants in these areas.

INTRODUCTION

The Honey Possum (*Tarsipes rostratus*) is a tiny (7–12 g) highly specialised marsupial that feeds exclusively upon pollen and nectar to meet all of its nutritional requirements. A high metabolic rate means that they need to feed daily (Renfree *et al.* 1984). Endemic to the south west of Western Australia, the Honey Possum inhabits coastal sandplain heathlands rich in the proteaceous and myrtaceous species that provide most of the inflorescences upon which it feeds.

There are several threats to the vegetation that provides the foodplants and cover upon which the Honey Possum depends for its survival. These threats may include clearance and fragmentation, inappropriate fire regimes, decreased rainfall, and the root-rot fungus *Phytophthora cinnamomi.* Some of these threats have been studied in areas inhabited by Honey Possums on the south coast of Western Australia, including the Fitzgerald River National Park (Wooller *et al.* 2008, Everaardt 2003, Wooller *et al.* in prep.) and the Scott National Park (Bradshaw *et al.* 2007).

Fire abruptly, and often severely, modifies small mammal habitat by reducing food supply and removing cover (Bowland and Perrin 1988), and the responses to fire of many animals are mediated by the changes to these critical resources (Driessen *et al.* 1991). It is not surprising, therefore, that the Honey Possum, a non-flying small mammal that is completely dependent upon a limited suite of nectar- and/or pollen rich plants to meet all of its nutritional requirements, is severely impacted by fire. Thus, the reduction or absence of flowering foodplants might contribute to the observed reduction in the capture rates of Honey Possums following fire (Wooller *et al.* in prep., Everaardt 2003).

The foodplants most frequently visited by Honey Possums at the western end of the Fitzgerald River National Park were *Banksia nutans* in summer and *B. baueri* in winter (Everaardt 2003). Both of these plants have flowers that are rich in pollen and nectar, vital to the Honey Possum's survival. This paper reports information on the heights and flowering of these two potential foodplants, as well as another potential foodplant (*Dryandra plumosa*), in relation to the time since the vegetation was last burnt.

METHODS

Study area

The Fitzgerald River National Park is located on the central south coast of Western Australia. It is one of the largest and most botanically rich national parks in Australia, and covers an area of almost 330,000 ha (Moore *et al.* 1991).

The study sites were located at the western end of the Park (Figure 1). The trapping grids were established within four areas with different fire histories. At the time of this study, Area 1 (Grids 1a and 1b) was last burnt more than 50 years ago. Long-term residents of the area confirm that this area has had no fires in living memory, and the vegetation in this area appears to have changed little over the 19 years of research in the area (R.



Clockwise from top: *Banksia baueri*. Photographed in garden at Sawyers Valley, Eric McCrum. *Banksia nutans*. Photographed in Two Peoples Bay, Eric McCrum. Honey possum in Scott National Park. Photo Don Bradshaw. *Dryandra plumosa*. Photographed in Fitzgerald River National Park, Margaret Pieroni.

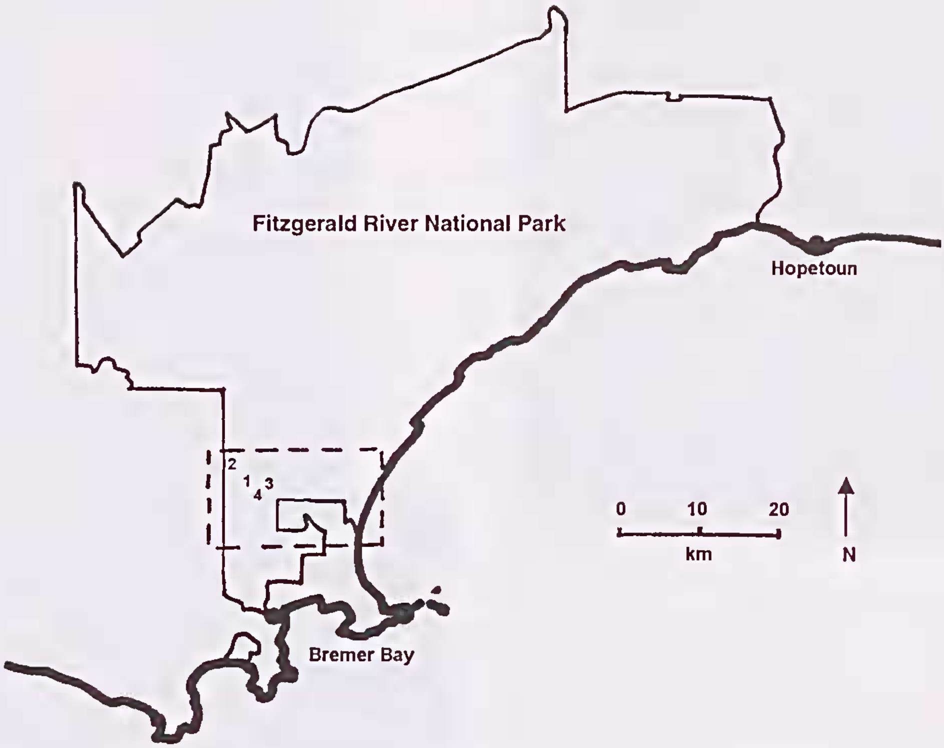


Figure 1. Location of trapping areas within the Fitzgerald River National Park. For further details on distances between trapping areas and between grids see Everaardt (2003).

Wooller, personal communication). This is supported by the maturity of the vegetation and the senescence of some of the plants in the grids. A similar fire history was arrived at based on aerial photographs of the area (Moore *et al.* 1991). Area 2 (Grid 2) was last burnt in a prescribed management burn in March 1980. The 1980 fire was a low intensity ("cool") burn of a strip of vegetation between two firebreaks some 200 to 300 m apart, with long unburnt vegetation remaining unburnt on both sides throughout the study. There was no indication of fire before 1980 in the immediate area (Saffer 1998) and prior to this fire Area 2 appears to have been unburnt for at least 37 years (Moore *et al.* 1991).

Area 3 (Grids 3a and 3b) was last burnt in December 1989 following a series of lightning strikes over a two-week period. Some 37 % of the Park was burnt in these high intensity ("hot") wildfires, the largest on record for the Park (McCaw *et al.* 1992). Prior to the 1989 fires, it was estimated that the area had been unburnt for at least 32 years (Moore *et al.* 1991). Area 4 (Grids 4a and 4b) was last burnt in May 1998. The fire started as a prescribed management burn for fuel reduction, but became more widespread than expected. The intensity of the fire was variable as it travelled some 8 to 10 km along a front from a few hundred metres to 1–2 km wide. Prior to this fire, Area 4 was estimated to have been unburnt for at least 51 years (Moore *et al.* 1991).

Size-class distributions of three potential foodplants

The height of 50 plants each of *Banksia baueri*, *B. nutans*, and *Dryandra plumosa* at six trapping grids was measured in March 2003. At this time, the age of the vegetation at the grids ranged from nearly five years old (Grids 4a and 4b) to > 50 years old (Grids 1a and 1b). These three foodplants featured prominently in the study of pollen loads taken from Honey Possums, reported in Everaardt 2003, and were present in samples taken from individuals caught in the most recently burnt Area 4, as well as from animals caught in areas longer unburnt. The two banksia species regenerate only from seed, and grow only slowly, whilst *D. plumosa* can regenerate from an underground lignotuber, as well as from seed (George 1984).

The heights of the first 50 plants of each of these species encountered at each grid were measured to ± 1 cm. The only exception to this protocol was at dense and long unburnt Grids 1a and 1b, where only 30 plants of *B. baueri* and *B. nutans* were measured, and then only plants that could be accessed without undue trampling of the vegetation; this minimised the risk of vegetation damage and disturbance to fauna. In addition, only 19 *D. plumosa* plants were visible from the tracks at Grid 1a, and only 4 plants at Grid 1b; thus, only these 23 plants were measured at this area.

Flowering indices of three potential foodplants

A flowering index was recorded for each of the species whose heights were measured. This flowering index was the number of inflorescences (developing, fresh, and those from previous seasons) on each plant measured. Those plants that had yet to flower were recorded as such. Developing, fresh and older inflorescences were recorded because the study was completed at the beginning of autumn when at least two of the three plant species were not in their normal flowering period; *Banksia baueri* is a winter flowering plant and *B. nutans* a summer flowering plant, whereas *Dryandra plumosa* flowers for much of the year. Only some indication of whether plants had flowered was sought, accordingly no detailed statistical analyses were performed.

RESULTS

Size-class distributions of three potential foodplants

Table 1 shows the median and mean (± 1 S.E.) height for the *Banksia baueri*, *B. nutans* and *Dryandra plumosa* plants measured at each of the seven trapping grids. In general, the median and mean heights of all three species were similar at trapping grids in the same area (Table 1). All three species were taller in areas longer unburnt (Table 1).

Figure 2 shows the percentage frequency distributions of seven height categories for each of the foodplant species measured. Almost all plants sampled at Grids 4a and 4b, and also at Grids 3a and 3b, were less than 76 cm in height, and all were less than 101 cm (Figure 2). In contrast, at Grids 1a and 1b, 80 % or more of the *B. baueri* plants and more than 90 % of *B. nutans* plants sampled were taller than 75 cm, and all of the *D. plumosa* plants were taller than 50 cm (Figure 2). Plants at Grid 2 were, on average, similar in height to those at Grids 1a and 1b (Figure 2).

Flowering indices of three potential foodplants

Shown in Figure 3 are the percentage frequency distributions of the indices of flowering for the *Banksia baueri*,

Table 1. The median and mean (± 1 S.E.) heights of the *Banksia baueri* (top), *B. nutans* (centre) and *Dryandra plumosa* (bottom) plants measured in March 2003.

Grid	Years since last burnt	Median height (cm)	Mean (± 1 S.E.) height (cm)
		Banksia baueri	
1a	> 50	98.0	97.4 ± 3.1
1b	> 50	87.0	86.9 ± 2.1
2	23	84.0	83.2 ± 1.9
3a	13	55.5	54.8 ± 1.3
3b	13	49.0	50.9 ± 1.7
4a	5	38.0	38.4 ± 1.1
4b	5	42.0	41.9 ± 1.1
		Banksia nutans	
1a	> 50	119.5	123.6 ± 4.3
1b	> 50	110.5	112.0 ± 4.0
2	23	83.0	84.9 ± 2.1
3a	13	50.0	51.3 ± 1.7
3b	13	45.0	47.2 ± 1.3
4a	5	27.5	28.6 ± 0.7
4b	5	27.0	27.1 ± 0.7
		Dryandra plumosa	
1a	> 50	70.0	78.0 ± 5.4
1b	> 50	78.0	84.3 ± 14.0
2	23	70.5	70.5 ± 2.4
3a	13	45.5	48.3 ± 1.9
3b	13	42.5	42.6 ± 1.5
4a	5	30.0	31.0 ± 1.0
4b	5	25.0	27.6 ± 1.3

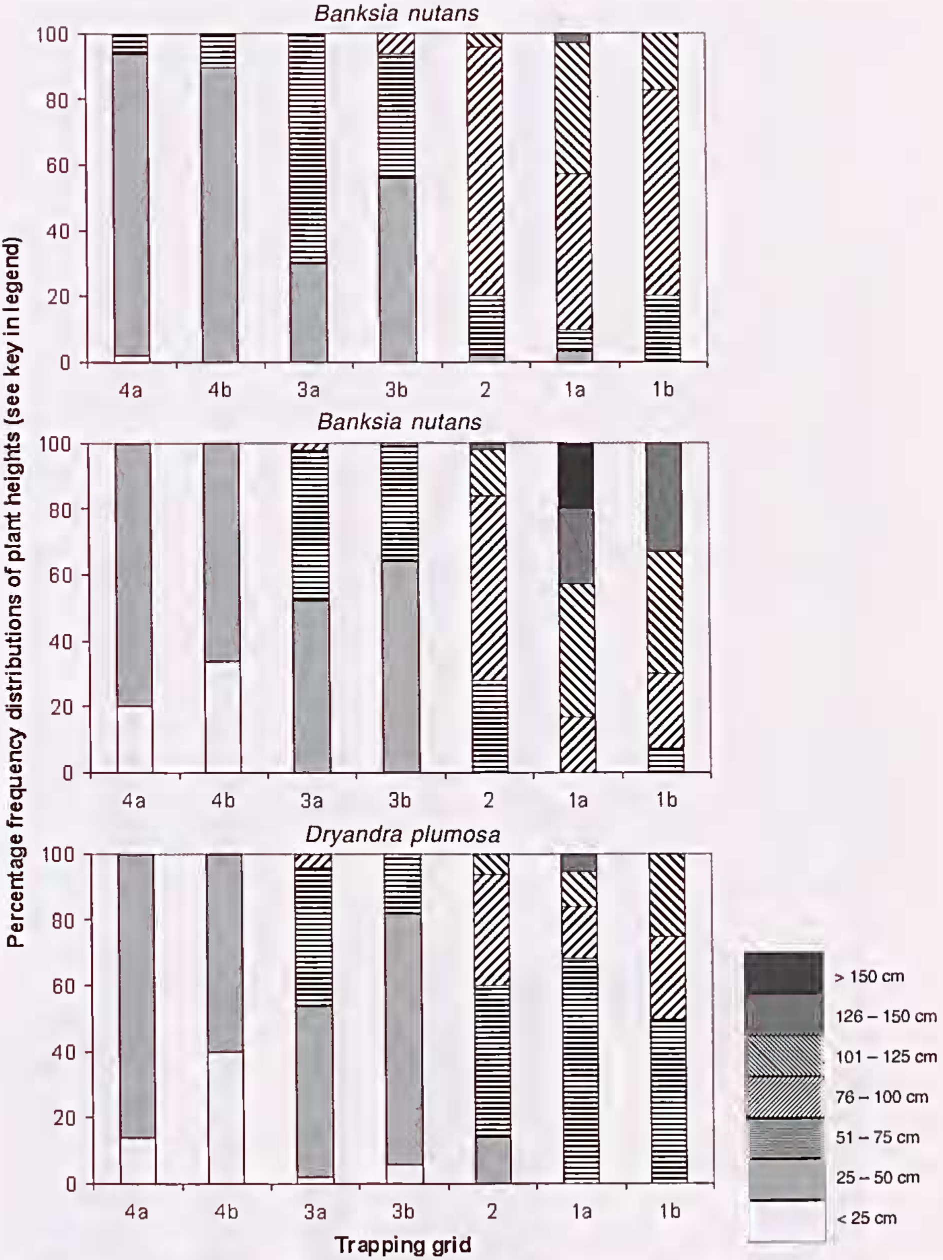
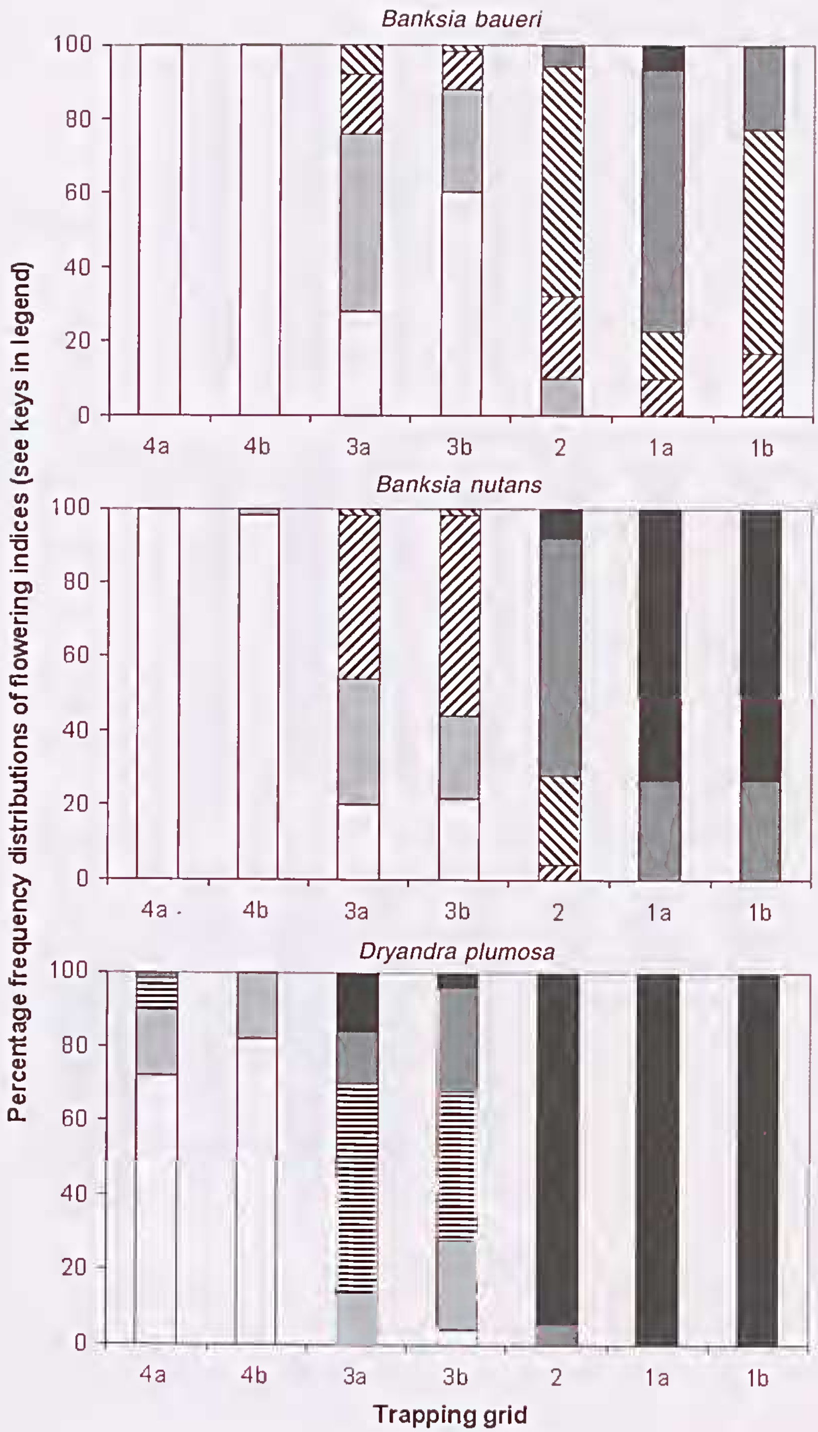


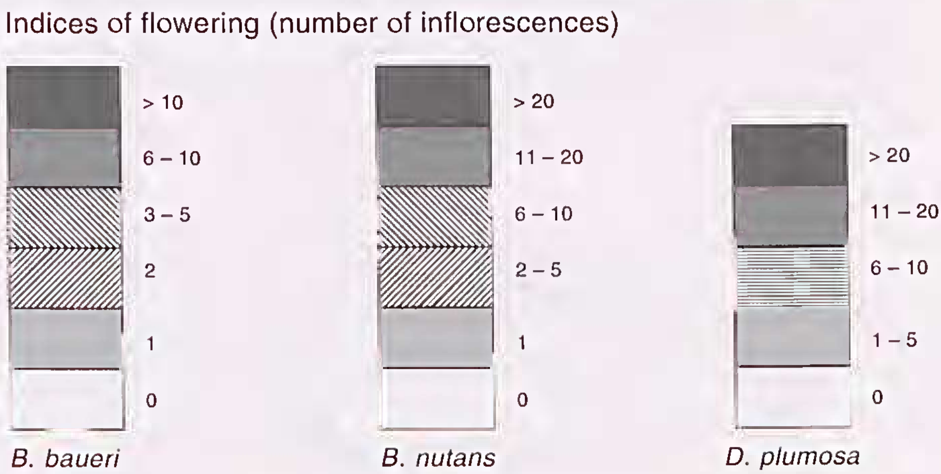
Figure 2. The percentage frequency distributions of plant heights (see key above) for three potential Honey Possum foodplants, *Banksia baueri* (top), *B. nutans* (centre) and *Dryandra plumosa* (bottom). Data were collected in March 2003, at which time the vegetation at Grids 4a and 4b was about five years old, at Grids 3a and 3b it was about 13 years old, at Grid 2 it was about 23 years old and at Grids 1a and 1b it was at least 50 years old.

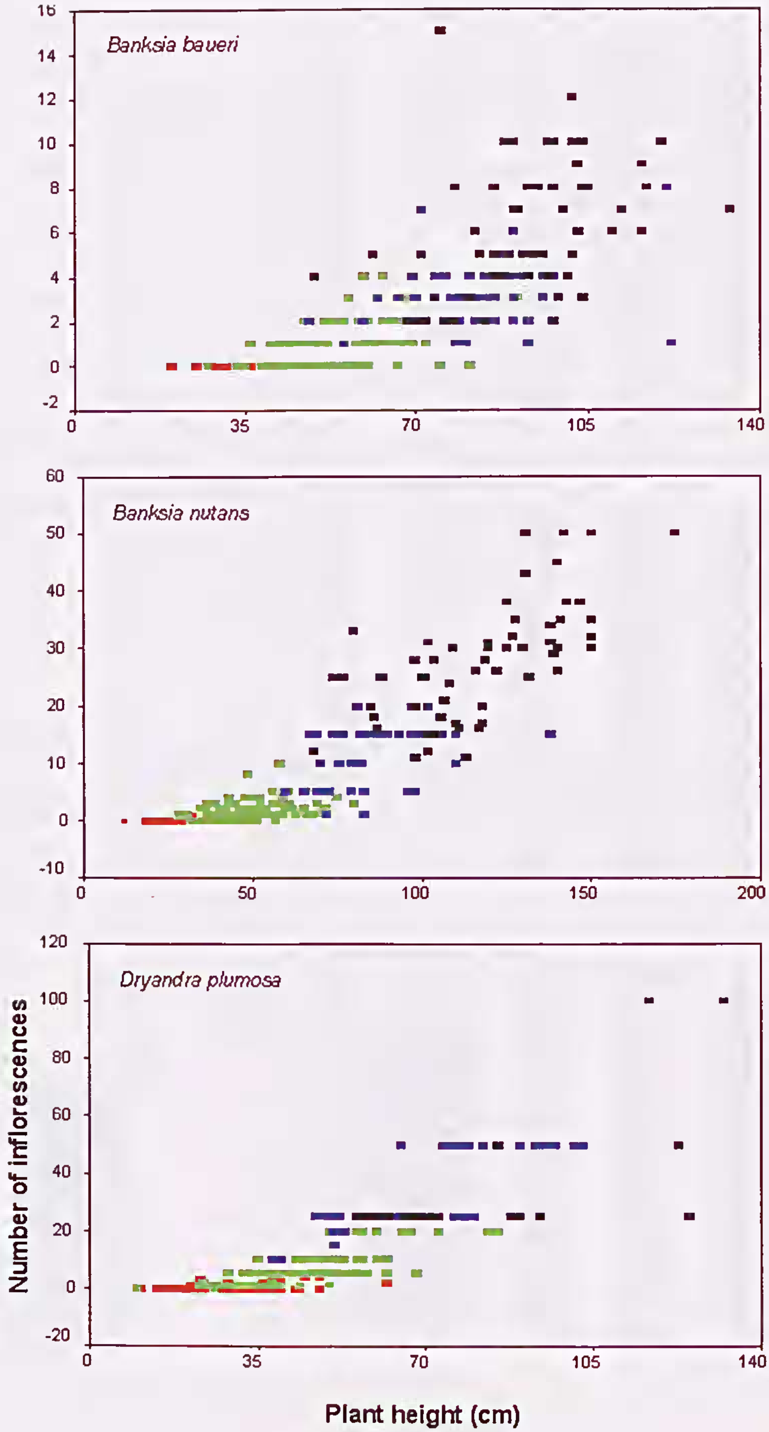

Banksia baueri
Banksia nutans
Dryandra plumosa
Percentage frequency distributions of flowering indices (see keys in legend)
Trapping grid
4a
4b
3a
3b
2
1a
1b
0
20
40
60
80
100

B. nutans and *Dryandra plumosa* plants sampled. At Area 4, most recently burnt in May 1998, none of the *B. baueri* plants sampled in March 2003 showed any evidence of flowering (Figure 3), even though the first post-fire record of flowering by *B. baueri* at this area was in July 2002 (Everaardt 2003). Of the *B. baueri* plants sampled at Area 3, most (95 %) had less than three inflorescences, and many (44 %) had still not flowered (Figure 3). In contrast, all *B. baueri* plants at Area 2 had at least one inflorescence, and many (68 %) had three or more (Figure 3). At Area 1, all had at least two inflorescences and most (87 %) had more than three (Figure 3).

Of the *B. nutans* plants sampled at Area 4, only 1 % showed any evidence of flowering (Figure 3). It is worth noting, however, that another eight plants within the boundaries of Grids 4a and 4b had shown evidence of flowering since the fire in 1998. The first post-fire record of flowering was in January 2002, when only a single, small, inflorescence was recorded on each of the plants involved, all of which were less than 40 cm in height (Everaardt 2003). Of the *B. nutans* plants sampled at Area 3, most (98 %) had less than six inflorescences and some (21 %) had never flowered (Figure 3). In contrast, all of the *B. nutans* plants sampled at Area 1, and

◀ **Figure 3.** The percentage frequency distributions of the indices of flowering (see keys below) for three potential honey possum foodplants, *Banksia baueri* (top), *B. nutans* (centre) and *Dryandra plumosa* (bottom). The flowering index was the number of developing, fresh and old inflorescences on each plant sampled. A zero count indicates that no evidence of flowering was observed on a plant. Data were collected in March 2003, at which time the vegetation at Grids 4a and 4b was about five years old, at Grids 3a and 3b it was about 13 years old, at Grid 2 it was about 23 years old and at Grids 1a and 1b it was at least 50 years old.





Banksia baueri
Banksia nutans
Dryandra plumosa
Number of inflorescences
Plant height (cm)

many (72 %) of the plants at Area 2, had more than ten inflorescences each. Moreover, 73 % of the plants sampled at Area 1 had more than 20 inflorescences (Figure 3).

Figure 3 also shows the flowering index for *D. plumosa*, a species that can regenerate from both lignotuber and seed. As for both *B. baueri* and *B. nutans* plants sampled at Area 4, most (77 %) of the *D. plumosa* plants sampled at this area had yet to show any evidence of flowering, and 95 % of plants had less than six flowers (Figure 3). In comparison, 79 % of the *D. plumosa* plants sampled at Area 3 each had six or more flowers, and only 2 % of plants had yet to flower (Figure 3). Although only 23 plants were sampled at Area 1, all had more than 20 flowers each. A similarly high value was recorded at Area 2, where most (94 %) of the *D. plumosa* plants sampled had more than 20 flowers each, and the rest had 11–20 flowers each (Figure 3).

Figure 4 shows the height of a plant in relation to the number of inflorescences it carried, a significant relationship for *B. baueri* ($r_{308} = +0.793$, $p < 0.001$) and *B. nutans* ($r_{308} = +0.902$, $p < 0.001$), as well as for *D. plumosa* ($r_{271} = +0.865$, $p < 0.001$). These relationships clearly indicate that despite substantial variation between plants in an area, those areas unburnt for longer had taller plants bearing more inflorescences (Figure 4).

DISCUSSION

The response patterns of small mammals after fire are closely tied to their food, shelter and breeding requirements (Friend 1993). One of the greatest impacts of fire on the Honey Possum would appear to be the removal of those foodplants upon which they depend for their survival. Many of these foodplants are slow growing and have a substantial time period, often exceeding five years, before they start flowering again after fire (Wooller *et al.* 2002). Thus, although those foodplants that regenerate only from seed are quick to establish seedlings in the aftermath of fire, these seedlings provide little habitat value or food (flowers) for Honey Possums.

The three foodplants selected for study, *Banksia baueri*, *B. nutans*

◀ **Figure 4.** The height of each *Banksia baueri* (top), *B. nutans* (centre) and *Dryandra plumosa* (bottom) plant sampled in relation to the number of inflorescences on that plant. Each coloured square represents one plant and the number of inflorescences includes developing, fresh and old inflorescences. Data were collected in March 2003, at which time the vegetation at Area 4 ■ was about five years old, at Area 3 ■ it was about 13 years old, at Area 2 ■ it was about 23 years old and at Area 1 ■ it was at least 50 years old.

and *Dryandra plumosa*, were those visited frequently by Honey Possums (Everaardt 2003). It appears likely that Honey Possums, in this area, depend upon specific seasonal foodplants, in particular *B. baueri* and *B. nutans*. Their foodplant preferences changed little despite spatial differences in availability, and it appears that they will travel some distance to satisfy these preferences (Everaardt 2003). Unlike the two banksia species, use of *D. plumosa* was not highly seasonal, but the frequency with which its pollen was carried by Honey Possums seemed to suggest that it was an important foodplant during most seasons (Everaardt 2003, Saffer 1998).

All three species of foodplants were recorded at all four areas, last burnt some 5, 13, 23 and > 50 years earlier. As expected, the height of foodplants increased with time since the vegetation was last burnt. In the most recently burnt area, however, the plants were young and the two banksia species were devoid of any flowers for the first four years. Not surprisingly, some of the *D. plumosa* plants, which can regenerate from lignotuber as well as from seed, flowered within a few years of the fire. The first post-fire flowering by *B. baueri*, after the May 1998 fire, was in July 2002, more than four years since the fire. However, the number of plants that flowered was so low compared to the number of seedlings within the area, that none of the 100 plants measured at this area had yet flowered. A similar interval to first post-fire flowering was recorded in *B. nutans*, with the first inflorescences recorded almost four years after the fire, all of them very small. So few *B. nutans* inflorescences were recorded that just 1 % of *B. nutans* plants measured had an inflorescence. Wooller *et al.* (2002) recorded similar intervals to time of first flowering in *B. baueri* and *B. nutans* for the same heathland after an earlier fire.

For the two obligate re-seeders, *B. baueri* and *B. nutans*, it was 13 years before more than half of the plants had flowered, and 23 years before all plants had flowered. The time to first flowering for the re-sprouting *D. plumosa* was more rapid. Within five years of fire, 23 % of plants had flowered and nearly all (98 %) had flowered within 13 years. The general trend, however, for each of the species of foodplants was that, despite the substantial variation reported within a species at an area, those areas unburnt for longer had taller plants bearing more inflorescences.

Although the nature of the data collected in this examination of foodplants precluded any detailed statistical analyses being performed, the increasing abundance of Honey Possums with increasing time since last fire, and maximal captures of Honey Possums in areas unburnt for some 30 years, corresponds well to the availability of their foodplants. At one burnt area, there were few flowering foodplants for at least 4–5 years after the fire, more plants had flowered at an area burnt some 12 years earlier, and by 22 years following fire most of their foodplants had flowered (Everaardt 2003).

Other studies undertaken on the impact of fire upon the Honey Possum in the Fitzgerald River National Park showed that there were four factors that significantly (statistically) affected the rates of capture of Honey Possums in this Park. These factors were: (i) the time elapsed since the vegetation was last burnt, (ii) annual rainfall in the preceding year, but not the current year, (iii) the season of the year, and (iiii) the trapping grid (Wooller *et al.* in prep., Everaardt 2003).

The availability of both obligate re-seeders and re-sprouters within the heathland vegetation of the Fitzgerald River National Park would seem to be of value to this flower-feeding specialist. Whilst it appears that Honey Possums prefer many foodplants that do not flower for many years following fire, the availability of plants such as *Dryandra plumosa*, *Calothamnus gracilis* and *Eucalytpus buprestium*, capable of flowering within a few years after fire, may provide the sustenance that they require as they search for their preferred foodplants which only flower in areas longer unburnt.

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